CLAIMS

We Claim:

1. An apparatus for utilizing a preform, having a first end and a second end, to manufacture an optical fiber having a modulation of the dielectric constant along its longitudinal axis, the apparatus comprising:

feeding means for:

securing the first end of the preform, and

feeding the preform at a predefined feeding speed;

heating means, arranged sequentially to said feeding means, for receiving the preform and for heating the preform to a predefined process temperature at a predefined heating location, said process temperature being sufficient to cause the preform to be susceptible to drawing and twisting; and

drawing means, arranged sequentially to said heating means, for:

engaging the second end of the preform;

drawing the preform from said feeding means through said heating means at a predefined drawing speed to produce the optical fiber drawn from the preform at said predetermined location within said heating means, said drawing speed being one greater than or equal to said feeding speed; and

twisting the optical fiber around the longitudinal axis at a predefined twisting speed, at said predetermined location, to produce a twisted optical fiber having a periodic modulation of the dielectric constant along the longitudinal axis.

2. The apparatus of claim 1, wherein the preform comprises at least one of:

(a) at least one hole along the longitudinal axis;

(b) at least one groove in the surface of the preform along the longitudinal axis;

(c) a first elongated quarter-cylindrical portion comprised of a first material, a second elongated quarter-cylindrical portion comprised of a second material, in contact with said first portion, a third elongated quarter-cylindrical portion comprised of a first material in contact with said second portion, and a fourth elongated quarter-cylindrical portion comprised of a second material in contact with said third and said first portions, said first, second, third and fourth portions being arranged clockwise starting from said first portion;

(d) a first elongated half-cylindrical portion comprised of a first material and a second elongated half-cylindrical portion comprised of a second material, said first and second portions having their flat surfaces in contact with one another;

(e) at least two elongated elements in contact with one another along a common longitudinal axis; and

(f) an outer cladding material and an inner core material along a central longitudinal axis, said outer cladding material having a circular cross-section, and said inner core material having one of: an elliptical cross-section and a rectangular cross-section.

3. The apparatus of claim 1, further comprising a control unit connected to said feeding means, said heating means, and said drawing means, said control unit being operable to: control and vary at least one of: said predefined feeding speed, said predefined process temperature, said predefined drawing speed and said predefined twisting speed.

4. The apparatus of claim 3, further comprising a translation means connected to said control unit, wherein said feeding means and said drawing means are each configured to move along said translation means, and wherein said control unit is operable to:

(a) cause said feeding means to move along said translation means at said feeding speed; and

(b) cause said drawing means to move along said translation means at said drawing speed.

5. The apparatus of claim 3, further comprising a translation means connected to said control unit, wherein said feeding means are configured to move along said translation means, and wherein said control unit is operable to:

(a) cause said feeding means to move along said translation means at said feeding speed; and

(b) cause said drawing means to draw the optical fiber from the heating means at said drawing speed.

6. The apparatus of claim 3, further comprising a translation means connected to said control unit, wherein said feeding means, said heating means, and said drawing means are each configured to move along said translation means, and wherein said control unit is operable to:

(a) cause said feeding means to move along said translation means at a first speed;

(b) cause said heating means to move along said translation means at a second speed; and

(c) cause said drawing means to move along said translation means at a third speed, wherein said first speed, said second speed, and said third speed are selected having magnitude and direction such that:

the difference between said first speed and said second speed is substantially equal in magnitude and direction to said feeding speed, and

the difference between said third speed and said second speed is substantially equal in magnitude and direction to said drawing speed.

7. The apparatus of claim 1, further comprising tensioning means for imposing a predefined tension on the preform, prior to activation of said feeding means, said heating means, and said drawing means.

8. The apparatus of claim 7, wherein said tensioning means further comprises:

securing means for securing the second end of the preform; and

pulling means for pulling the first end of the preform until said predefined tension is reached.

9. The apparatus of claim 8, wherein said tensioning means further comprises securing means for securing the first end of the preform after said predefined tension is reached.

10. The apparatus of claim 9, wherein said tensioning means further comprises means for disconnecting said pulling means from the preform first end after the first end of the preform is secured by said securing means.

11. The apparatus of claim 7, wherein said tensioning means comprises:

a wheel configured to freely rotate around an axis perpendicular to the longitudinal axis of the preform;

a line looped around said wheel, said line having a proximal end and a distal end, said proximal end being attached to the first end of the preform; and

a counterweight of a predefined magnitude attached to said distal end of said line, said counterweight magnitude being selected to apply said predefined tension to the preform.

12. The apparatus of claim 11, further comprising means for:

(a) after said predefined tension is applied to the preform, securing the first end of the preform; and

(b) disconnecting said line proximal end from the preform first end.

13. The apparatus of claim 7, wherein said tensioning means comprises:

a wheel configured to freely rotate around an axis perpendicular to the longitudinal axis of the preform; and

a counterweight of a predefined magnitude, wherein the preform first end is looped around said wheel and attached said counterweight, said counterweight magnitude being selected to apply said predefined tension to the preform.

14. The apparatus of claim 13, wherein the preform passes through said feeding means before entering said tensioning means, further comprising means for:

(a) after said predefined tension is applied to the preform, securing a portion of the preform within said feeding means; and

(b) severing the preform above said secured portion.

15. The apparatus of claim 7, wherein said tensioning means comprises a motor connected to the preform first end, operable to pull the preform first end until said predefined tension is applied to the preform.

16. The apparatus of claim 15, wherein the preform passes through said feeding means before entering said tensioning means, further comprising means for:

(a) after said predefined tension is applied to the preform, securing a portion of the preform within said feeding means; and

(b) severing the preform above said secured portion.

17. The apparatus of claim 7, wherein said tensioning means comprises:

a line having a proximal end and a distal end, said proximal end being attached to the first end of the preform; and

a motor connected to said distal end of the line, operable to pull said line until said predefined tension is applied to the preform.

18. The apparatus of claim 17, further comprising means for:

(a) after said predefined tension is applied to the preform, securing the first end of the preform; and

(b) disconnecting said line proximal end from the preform first end.

19. The apparatus of claim 1, wherein a diameter D_f of the drawn and twisted optical fiber is defined by the following expression:

$$D_f = D_p \sqrt{\frac{V_f}{V_d}}$$

wherein, D_p is a diameter of the preform, V_f is said feeding speed and V_d is said drawing speed.

20. The apparatus of claim 1, wherein a pitch P of the drawn and twisted optical fiber is defined by the following expression:

$$P = \frac{V_d}{R}$$

wherein, V_d is said drawing speed and R is said twisting speed.

21. The apparatus of claim 1, wherein said heating means comprises a central portion, said heating means further comprising first heat control means for imposing a substantially flat transverse heat distribution perpendicular to the preform and the optical fiber drawn therefrom in said central portion of said heating means.

22. The apparatus of claim 21, wherein said first heat control means comprise at least one of: insulating means disposed within said heating means, and active cooling means applied to at least portion of said heating means.

23. The apparatus of claim 21, wherein said heating means comprises an upper portion for receiving the preform and a bottom portion for releasing the optical fiber, said heating means further comprising a second heat control means for imposing a longitudinal heat distribution along the preform and the optical fiber drawn therefrom, said longitudinal heat distribution increasing from a minimal temperature at said upper portion of said heating means to a peak process temperature, said peak being positioned at said central portion of said heating means, and dropping to said minimal temperature approximately immediately after said central portion of said heating means.

24. The apparatus of claim 23, wherein said second heat control means comprise at least one of: insulating means disposed within said heating means, and active cooling means applied to at least portion of said heating means.

25. The apparatus of claim 21, wherein said heating means comprises an upper portion for receiving the preform and a bottom portion for releasing the optical fiber, said heating means further comprising a third heat control means for imposing a longitudinal heat distribution along the preform and the optical fiber drawn therefrom, said longitudinal heat distribution sharply increasing to a peak process temperature at said central portion of said heating means and remaining at a substantially minimal level in other portion of said heating means.

26. The apparatus of claim 25, wherein said third heat control means comprise at least one of: insulating means disposed within said heating means, and active cooling means applied to at least portion of said heating means.

27. The apparatus of claim 3, further comprising tensioning means for applying a predefined tension to the preform, wherein said control unit is further operable to:

(a) prior to activation of said feeding means, said heating means, and said drawing means, activate said tensioning means to apply said predefined tension to the preform;

(b) cause said feeding means to feed the preform at a first feeding speed, and cause said drawing means to draw the preform at said predefined drawing speed, wherein said first feeding speed is equal to said predefined drawing speed;

(c) activate said heating means to increase an internal temperature from an initial temperature to said process temperature; and

(d) while increasing said internal temperature from said initial temperature to said process temperature, decrease said first feeding speed such that said first feeding speed reaches said predefined feeding speed when said internal temperature reaches said process temperature.

28. The apparatus of claim 1, wherein said heating means comprises a longitudinal heating chamber surrounding the preform, the preform being disposed along a central longitudinal axis of said heating chamber, and wherein said heating chamber

comprises an elongated cross section such that heat distribution applied to the preform is uneven but symmetrical along the sides of the preform.

29. The apparatus of claim 28, wherein the preform comprises a solid glass element.

30. A method for fabricating an optical fiber having a modulation of the dielectric constant along its longitudinal axis from a preform having a first end and a second end, the method comprising the steps of:

(a) securing the first end of the preform;

(b) feeding the preform at a predefined feeding speed through a heating unit;

(c) heating the preform to a predefined process temperature at a predetermined location in said heating unit, said process temperature being sufficient to cause the preform to be susceptible to drawing and twisting; and

(d) engaging the second end of the preform;

(e) drawing the preform through said heating unit at a predefined drawing speed to produce the optical fiber drawn from the preform at said predetermined location within said heating unit, said drawing speed being greater than or equal to said feeding speed; and

(f) twisting the optical fiber around the longitudinal axis at a predefined twisting speed, at said predetermined location, to produce a twisted optical fiber having a periodic modulation of the dielectric constant along the longitudinal axis.

31. The method of claim 30, wherein the preform comprises at least one of:

(a) at least one hole along the longitudinal axis;

(b) at least one groove in the surface of the preform along the longitudinal axis;

(c) a first elongated quarter-cylindrical portion comprised of a first material, a second elongated quarter-cylindrical portion comprised of a second material, in contact with said first portion, a third elongated quarter-cylindrical portion comprised of a first material in contact with said second portion, and a fourth elongated quarter-cylindrical portion comprised of a second material in contact with said third and said first portions, said first, second, third and fourth portions being arranged clockwise starting from said first portion;

(d) a first elongated half-cylindrical portion comprised of a first material and a second elongated half-cylindrical portion comprised of a second material, said first and second portions having their flat surfaces in contact with one another;

(e) at least two elongated elements in contact with one another along a common longitudinal axis; and

(f) an outer cladding material and an inner core material along a central longitudinal axis, said outer cladding material having a circular cross-section, and said

inner core material having one of: an elliptical cross-section and a rectangular cross-section.

32. The method of claim 30, further comprising the step of:

(g) providing a control unit operable to: control and vary at least one of: said predefined feeding speed, said predefined process temperature, said predefined drawing speed, and said predefined twisting speed.

33. The method of claim 30, further comprising the step of:

(h) imposing a predefined tension on the preform, prior to said step (a).

34. The method of claim 33, wherein said step (h) further comprises the steps of:

(i) securing the second end of the preform; and

(j) pulling the first end of the preform until said predefined tension is reached.

35. The method of claim 30, wherein a diameter D_f of the drawn and twisted optical fiber is defined by the following expression:

$$D_f = D_p \sqrt{\frac{V_f}{V_d}}$$

wherein, D_p is a diameter of the preform, V_f is said feeding speed and V_d is said drawing speed.

36. The method of claim 30, wherein a pitch P of the drawn and twisted optical fiber is defined by the following expression:

$$P = \frac{V_d}{R}$$

wherein, V_d is said drawing speed and R is said twisting speed.

37. The method of claim 30, further comprising the step of:

(k) imposing a substantially flat transverse heat distribution perpendicular to the preform in said predetermined portion of said heating unit.

38. The method of claim 30, further comprising the step of:

(l) imposing a longitudinal heat distribution along the preform and the optical fiber drawn therefrom, said longitudinal heat distribution increasing from a minimal temperature at a point of entry of the preform into the said heating unit to a peak process temperature at said predetermined location within the heating unit, and dropping to said minimal temperature approximately immediately after said predetermined location.

39. The method of claim 30, further comprising the step of:

(m) imposing a longitudinal heat distribution along the preform and the optical fiber drawn therefrom, said longitudinal heat distribution sharply increasing to a peak process temperature at said predetermined portion in said heating unit, and remaining at a substantially minimal level in other portions of said heating unit.

40. The method of claim 30, further comprising the steps of:

(n) prior to said step (a), applying a predefined tension to the preform;

(o) at said step (b) feeding the preform at a first feeding speed;

(p) at said step (e) drawing the preform at said predefined drawing speed, wherein said first feeding speed is equal to said predefined drawing speed;

(q) at said step (c) increasing an internal temperature of said heating unit from an initial temperature to said process temperature; and

(r) while increasing said internal temperature from said initial temperature to said process temperature, decreasing said first feeding speed such that said first feeding speed reaches said predefined feeding speed when said internal temperature reaches said process temperature.